Allometric Equations for Perennial Grasses in the Desert Grassland

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Introduction

- Productivity and amount of standing biomass are critical to understand ecosystem function and response to management.
- Non-destructive estimates of biomass reduce the time investment and impact of destructive estimates.
- Allometric relationships provide non-destructive estimates of biomass based on size and mass relationships.
- Diameter is most strongly correlated with biomass although height and grazing history should improve the model.
- Allometric relationships should differ between plants with/ without long exposure to livestock grazing because repeated defoliation 1) removes standing biomass and 2) creates prostrate growth through increased tillering
- Therefore, we expect exposure to grazing to 1) reduce the total standing mass-size^{-1} relationship and 2) increase the productivity mass-size^{-1} relationship if increased tillering occurs.

Objectives

2. Generate the allometric relationships between total mass and productivity (green mass) for 8 common grass species in the Desert Grassland.
3. Compare the allometric relationships between plants exposed to different livestock grazing histories.

Methods

- Santa Rita Experimental Range (Pasture 2SW) grazed moderately since 1950, but ungrazed during current summer grazing season, and adjacent Rodent Station Exclosure ungrazed since 1903.
- 25-45 plants species^{-1} along a size (diameter) gradient collected in August 2005
- 8 species (species groups)
- *Aristida* species (ARI), *Bouteloua eriopoda* (BOER), *Digitaria californica* (DICA); *Eragrostis curvula* (ERCU), *E.lehmanniana* (ERLE), *Heteropogon contortus* (HECO), *Muhlenbergia porteri* (MUPO) and *Setaria leucopila* (SELE).
- HECO and BOER collected in ungrazed area only.

Measurements

- Plant Mass: Y_{Total} =total mass (g plant^{-1}) and Y_{Green}=total green mass (g plant^{-1}).
- Plant Size: D=basal diameter (cm) and H=tallest leaf collar (cm) (Figure 2).
- Grazing History (G): where 0 = ungrazed and 1=grazed, expressed as interaction with size (D*G and H*G).

Model Development

- Natural log transformation of mass and size to normalize residuals.
- Forward Stepwise Regression with p <0.05 for entry.

Results

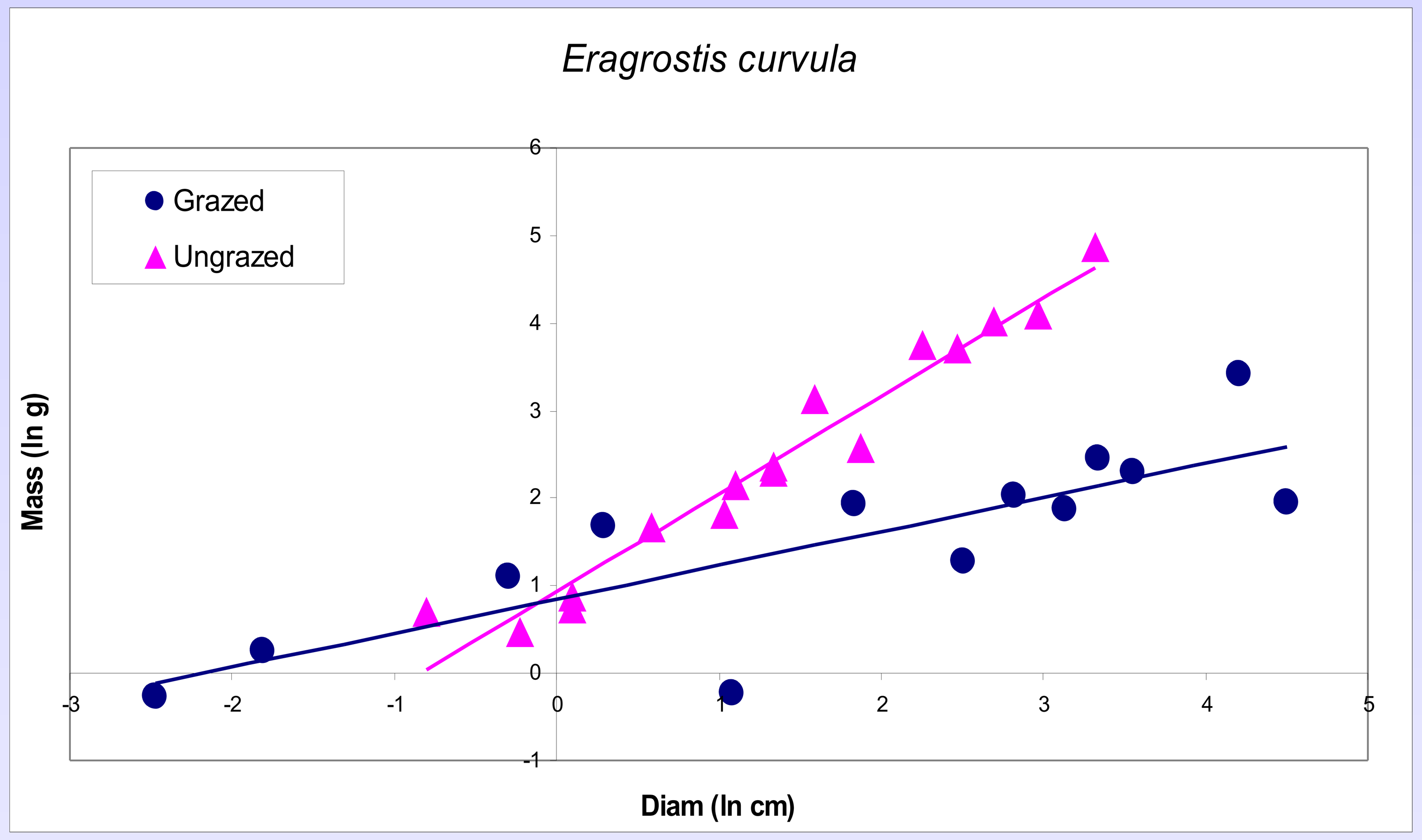

Figure 1. *Eragrostis curvula* showing effect of grazing on regression models for grazed and ungrazed mass by basal diameter

Table 1: Peak Seasonal Production (Summer Production) (Y_{Green})

Species	Model Parameters							R2	SEE
	Allometric models	Intercept	Diameter	Height	Diam* Grazing	Height* Grazing	n		
ARI	D+(D*G)	1.032	1.757		-0.687		28	0.878	0.476
BOER	D	0.448	1.335				22	0.855	0.521
DICA	D+H	-3.478	0.92	1.323			36	0.895	0.359
ERCU	D+(D*G)	0.885	1.136		-0.379		29	0.865	0.483
ERLE	D+H+(D*G)	-4.877	0.938	1.696	-0.225		35	0.960	0.382
HECO	D+H	-0.812	0.915	0.716			20	0.931	0.384
MUPO	D+H	-5.81	0.863	2.214			34	0.917	0.453
SELE	D+H+(H*G)	-1.601	1.22	0.809		-0.084	36	0.928	0.419

Table 2: Total Standing Biomass (Y_{Total})

Species	Model Parameters							R2	SEE
	Allometric models	Interce pt	Diameter	Height	Diam* Grazing	Height* Grazing	n		
ARI	D+D*G	1.101	1.798		-0.683		28	0.877	0.472
BOER	D	0.813	1.473				22	0.900	0.466
DICA	D+H+(D*G)	-3.816	1.272	1.416	-0.244		36	0.946	0.323
ERCU	D+(D*G)	1.093	1.282		-0.407		29	0.913	0.427
ERLE	D+H	-4.877	0.838	1.726			35	0.954	0.404
HECO	D+H	-0.812	0.915	0.716			20	0.937	0.388
MUPO	D+H	-4.93	0.97	2.046			34	0.912	0.494
SELE	D+H+(H*G)	-1.366	1.269	0.771		-0.112	36	0.934	0.411

Figure 2: Basal diameter and height measurement

Results and Discussion

Objective 1

- Allometric models had strong R^2 values (> 0.88 and 0.86) and high confidence levels (SEE < 0.49 and 0.52) for Total Mass (Y_{Total}) and Summer Productivity (Y_{Green}), respectively (Table 1 and Table 2).
- Diameter (D) was the most significant explanatory variable, and height was included as an explanatory variable included in most models (Table 1 and Table 2).

Objective 2:

- As expected, grazing history reduced the mass
- size^{-1} relationship for Total Mass (Y_{Total}), but this occurred in only 4 of 6 species (ARIS, DICA, ERCU, and SEMA; Table 2).
- Grazing history reduced the mass size^{-1} relationship for Green Mass (Y_{Green}) in 4 of 6 species (ARIS, ERCU, ERLE, and SEMA; Table 1, Figure 1).
- Reduction in the Green Mass size^{-1} relationship suggests that a long exposure to defoliation resulted in a concentration of mass in prostrate growth. This is especially apparent in SEMA where the grazing interaction was with height.

Implications

- Models can be used to accurately predict both peak seasonal biomass and total standing biomass on a site based on morphological measures of basal diameter and height and non-morphological site factors like grazing history.
- Grazing history is a significant explanatory variable for at least some species when creating allometric models and should be considered when attempting to predict biomass on a site

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